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Anvik River Sonar Chum Salmon Escapement Study, 2007

Final Report for Project 05-208
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Fisheries Information Services Division

by

Malcolm S. McEwen

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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Malcolm S. McEwen

Alaska Department of Fish and Game, Division of Commercial Fisheries, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518

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Malcolm S. McEwen,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
1300 College Road, Fairbanks, AK 99701, USA

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ABSTRACT

The 2007 Anvik River sonar project operated from late June until the end of July to estimate the passage of summer chum salmon *Oncorhynchus keta*. Data from each bank was collected using a high frequency imaging sonar (DIDSON) sonar sampling 30 minutes of each hour, 24 hours a day, 7 days a week. The estimated summer chum salmon passage of 459,038 (SE 1,881) was 24% above the minimum escapement objective for the Anvik River Biological Escapement Goal of 350,000 to 700,000 chum salmon. Based on 1979–1985 and 1987–2005 mean quartile passage dates, timing of the 2007 chum salmon run was average. A chum salmon diurnal migration pattern was observed with the highest passage (41%) occurring during the darkest part of the day (2100–0500 hours). Females comprised 58.2% of the catch in beach seines. Age-0.3 fish comprised 60.5% of the chum salmon run in 2007.

Key words: chum salmon, *Oncorhynchus keta*, pink salmon, *O. gorbuscha*, sonar, DIDSON, Anvik River

INTRODUCTION

The purpose of the Anvik River sonar project is to monitor escapement of summer chum salmon *Oncorhynchus keta* to the Anvik River drainage, believed to be the largest producer of summer chum salmon in the Yukon River drainage (Bergstrom et al. 1999). Additional major spawning populations of summer chum salmon occur in the following tributaries of the Yukon River: the Andreafsky River, located at river kilometer (rkm) 167; Rodo River (rkm 719); Nulato River (rkm 777); Melozitna River (rkm 938); and Tozitna River (rkm 1,096). Spawning tributaries in the Koyukuk River (rkm 817) drainage are the Gisasa River (rkm 907) and Hogatza River (rkm 1,255); and in tributaries to the Tanana River (rkm 1,118) drainage, which include the Chena River (rkm 1,480) and the Salcha River (rkm 1,553) (Figure 1). Chinook salmon *O. tshawytscha* and pink salmon *O. gorbuscha* spawn in the Anvik River concurrently with summer chum salmon. Pink salmon return to spawn during even numbered years and are apportioned out of the estimate. Chinook salmon are a minor component of the total return and are estimated separately via aerial surveys. Fall chum, a later run of chum salmon, and coho salmon *O. kisutch* have been reported to spawn in the Anvik River drainage during the fall.

Timely and accurate reporting of information from the Anvik River sonar project helps Yukon River fishery managers ensure the Anvik River Biological Escapement Goal (BEG) of 350,000 to 700,000 summer chum salmon is met. This assessment is necessary to determine if summer chum salmon abundance will meet upstream harvest and escapement needs.

Side-looking sonar, capable of detecting migrating salmon along the banks, has been in place in the Anvik River since 1980. The Electrodynamics Division of the Bendix Corporation[1] developed the side-looking sonar and conducted a pilot study using the side-looking sonar to estimate chum salmon escapement to the Anvik River in 1979. The results indicated sonar-based estimation of chum salmon escapements to the Anvik River was superior to the counting tower method used at that time (Mauney and Buklis 1980). Bendix sonar equipment was used for escapement estimates from 1979 to 2003. In 2003, a side-by-side comparison was done with Hydroacoustic Technology Incorporated (HTI) sonar equipment where it was found that the Bendix and HTI produced similar abundance estimates (Dunbar and Pfisterer 2007). In 2004, the switch was made to HTI sonar equipment. In 2006 a side-by-side comparison was done between HTI and DIDSON sonar, high water for most of the season prevented normal operation of the

[1] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

split-beam, but it was found the DIDSON abundance estimate was 61% higher than the split-beam abundance estimate (McEwen 2007).

BACKGROUND INFORMATION

Commercial and subsistence harvests of Anvik River chum salmon occur throughout the mainstem Yukon River, from the delta to the mouth of the Anvik River and within the first 19 km of the Anvik River. This section of the Yukon River includes Lower Yukon Area Districts 1, 2, and 3, and the lower portion of Subdistrict 4-A in the Upper Yukon Area (Figure 1). Most of the effort and harvest of this stock occurs in Districts 1 and 2, and in the lower portion of Subdistrict 4-A below the confluence of the Anvik and Yukon Rivers.

In the Lower Yukon Area, run timing of summer chum and Chinook salmon overlap, with runs beginning at river ice breakup in late May/early June and continuing through July. During this time commercial fisheries in the Lower Yukon Area have traditionally targeted Chinook salmon, while Subdistrict 4-A commercial fisheries have targeted summer chum salmon. In the Lower Yukon Area, large-mesh gillnets (stretch mesh greater than 15.2 cm) were employed to harvest Chinook salmon. Although these nets were efficient for Chinook salmon, the associated harvest of summer chum salmon through 1984 was minor in relation to the size of the chum salmon run. In order to allow directed harvests of summer chum salmon in the Lower Yukon, the Alaska Board of Fisheries (BOF), prior to the 1985 season, adopted regulations allowing fishing periods restricted to small-mesh gillnets (15.2 cm maximum stretch mesh) during the Chinook salmon season provided that (1) the summer chum salmon run was of sufficient size to support additional exploitation, and (2) incidental harvest of Chinook salmon during these small-mesh fishing periods did not adversely affect conservation of that species.

Increased market demand prompted allocation disputes between fishers in different districts. In February of 1990, the BOF established a guideline harvest range of 400,000 to 1,200,000 summer chum salmon for the entire Yukon River, allocated by district and sub-district based on the average harvests of the previous 15 years (ADF&G 1990). Summer chum salmon escapement to the Anvik River exceeded the lower range of the Anvik River BEG (Clark and Sandone 2001) of 400,000 salmon by an average of 233,000 salmon from 1979 to 1993. In 2004 the BOF established a BEG for the Anvik River of 350,000–700,000 (ADF&G 2004).

In 1994, the BOF adopted the Anvik River chum salmon fishery management plan, which permits a commercial harvest of summer chum salmon in the terminal Anvik River Management Area (ARMA, ADF&G 1994) to allow commercial exploitation of surplus chum salmon returning to the Anvik River. In 1996, the BOF established a harvest limit of 100,000 pounds of chum salmon roe for the ARMA (JTC 1996). A more complete history and background information can be found in Annual Management Reports for the Yukon Area published each year by the Alaska Department of Fish and Game (ADF&G).

OBJECTIVES

The objectives of the Anvik River sonar project are to:

1. Estimate fish abundance in the Anvik River with user-configurable sonar equipment by sampling every half hour 24 hours a day on both banks throughout the bulk of the chum salmon migration (approximately June 20 through July 26).

2. Estimate age, sex, and length (ASL) composition of the total Anvik River chum salmon escapements from a minimum of 2 to 3 pulse samples collected from each third of the run, such that simultaneous 95% confidence intervals of age composition in each pulse are no wider than 0.20 (α=0.05 and d=0.10).
3. Monitor selected climatic and hydrological parameters daily at the project site for use as baseline data.

In addition to these primary objectives, a HTI split-beam sonar was operated side-by-side with the DIDSON sonar to determine if corrections will be necessary to allow using historical data in conjunction with the new imaging estimates for making management decisions.

METHODS

STUDY AREA

The Anvik River originates at an elevation of 400 m and flows in a southerly direction approximately 200 km to its mouth at rkm 512 of the Yukon River (Figure 1). This narrow runoff stream has a substrate of mainly gravel and cobble. Bedrock is exposed in some of the upper reaches. The Yellow River (Figure 2) is a major tributary of the Anvik drainage and is located approximately 100 km upstream from the mouth of the Anvik River. Downstream from the confluence of the Yellow River, the Anvik River changes from a moderate-gradient system to a low-gradient system meandering through a much broader flood plain. Turbid waters from the Yellow River greatly reduce water clarity of the Anvik River below their confluence. Numerous oxbows, old channel cutoffs, and sloughs are found throughout the lower Anvik River.

The Anvik river, at the sonar site, is characterized by broad meanders, with large gravel bars on the inside bends and cut banks with exposed soil, tree roots, and snags on the outside bends. As with past years, we were able to use the same location, due to the site’s stability. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. The right bank slopes gradually to the thalweg at roughly 25–35 m, while the left bank river bottom slopes steeply to the thalweg at about 10–15 m, depending on water level.

Anvik River salmon escapements were partially estimated from visual counts made at counting towers above the confluence of the Anvik and Yellow Rivers, from 1972 to 1979 (Figure 2). A site 9 km above the Yellow River, on the mainstem Anvik River, was used from 1972 to 1975 (Lebida 1973[2]; Trasky 1974, 1976; Mauney 1977). From 1976 to 1979, a site on the mainstem Anvik River, near the confluence of Robinhood Creek and the Anvik River, was used (Figure 2; Mauney 1979, 1980; Mauney and Geiger 1977). Since 1979, the Anvik River sonar project has been located approximately 76 km upstream of the confluence of the Anvik and Yukon Rivers, 5 km below Theodore Creek (Figure 2) in Sections 34 and 35, Township 31 North, Range 61 West, Seward Meridian, at latitude/longitude 62° 44.208” N 160° 40.724” W. The land is public, managed by the Bureau of Land Management (BLM), and leased to ADF&G for public purposes until 2023. Aerial survey data indicate chum salmon spawn primarily upstream of this sonar site.

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[2] Lebida, R. C. Unpublished. Yukon River anadromous fish investigations, 1973. Alaska Department of Fish and Game, Juneau.

HYDROACOUSTIC DATA ACQUISITION

Equipment

Two DIDSON units were deployed at the Anvik sonar site, one for each bank. The sonar units operated at 1.1 MHz. Each DIDSON was mounted on an aluminum pod and manually aimed.

Each DIDSON was controlled by a laptop computer running either version 5.09 or 5.11 of the DIDSON software. A 152.4 m cable transferred power and data between a “breakout box” and the DIDSON unit in the water. For the right bank, a Honda model EU-2000 generator provided power for all equipment. An Ethernet cable routed data between the breakout box and a 10/100 BT hub and then to a laptop computer. A 500 GB RAID enclosure was connected to the laptop for storing of all data from both banks (Figure 3). The enclosure was configured as RAID 1 allowing redundant copies of the data on two separate hard drives within the enclosure in the event one of the hard drives failed.

The left bank sonar electronic equipment was housed in a 3.0 by 3.7 m (10 by 12 ft) portable wall tent and the equipment was powered by a single Honda model EU-1000 generator. A wireless Ethernet router (D-Link DWL-2100AP) transferred the data from the left bank DIDSON to the controlling laptop on the right bank where the data were saved to the RAID drive (Figure 3).

Transducer Deployment

The transducers were attached to an aluminum pod, deployed on each bank, and oriented perpendicular to the current. The wide axis of each beam was oriented horizontally and positioned close to the river bottom to maximize residence time of targets in the beam. Transducers were placed offshore 4 to 10 m from the right bank, and 1 to 2 m from the left bank. Daily visual inspections confirmed proper placement and orientation of the transducers and alerted operators as to when the transducers needed to be repositioned to accommodate changing water levels. The majority of the river (66–85%, depending on water level) was ensonified by using the right bank transducer to sample outwards 20 m and the left bank transducer to sample outward 10 m.

Partial weirs were erected perpendicular to the current and extended from the shore out one to three meters beyond the transducers. These devices moved chum salmon, Chinook salmon, and other large fish offshore and in front of the transducers to prevent them from passing undetected behind the transducers. The 4.4 cm gap between weir pickets was selected to divert large fish (primarily chum and Chinook salmon) while allowing passage of small, resident, non-target species grayling, *Thymallus thymallus*, pike, *Esox lucius*, sucker, *Catostomus sp.*, whitefish, *Coregonus*.

Sampling Procedures

Sonar project activities commenced on June 28 and ended on July 26, 2007. Hydroacoustic sampling began at 0001 hours on June 28 on right and left bank and ran every day until 2359 hours on July 26. Passage estimates were available to fishery managers in Emmonak at 0810 hours daily.

Acoustic sampling was conducted on both banks at the top of each hour for 30 minutes, 24h a day, 7 days per week, except for short periods when the generator was serviced or transducer adjustments were made. This sampling was consistent with previous field seasons. Three fishery technicians operated and monitored equipment at the sonar site while rotating through shifts (one person per shift) occurring from 0600–1400, 1000–1800, and 1600–0100 hours. The technicians identified and tallied fish traces from the echogram recordings, the first shift counted fish from 0001–0800, the second shift counted fish from 0800–1600, and the third shift counted fish from 1600–2400. All fish were counted except for very small fish, which are assumed not to be salmon, counting was done manually using the echogram and marking fish traces with the computer mouse. The video was used to verify fish target and fish size. The number of fish traces were then summed over 60 minute periods and recorded onto forms. Completed data forms were entered into a spreadsheet and checked over by the crew leader. All data was saved to the RAID drive in 30 minute intervals during the eight hour shift for later review as an echogram and/or video.

Four times per day (0900, 1300, 1700, and 2000) on both banks, 15 minute tower counts were completed. All fish were counted by species going by the sonar upstream and downstream. These numbers were compared with the sonar count to verify the sonar was aimed correctly and species composition.

The crew recorded all project activities in a project logbook. The logbook was used to document daily events of sonar activities and system diagnostics. During each shift, crew members were required to: 1) read the log from the previous shift; 2) sign the log book, including date and time of arrival and departure; 3) record equipment problems, factors contributing to problems, and resolution of problems; 4) record equipment setting adjustments and their purpose; 5) record observations concerning weather, wildlife, boat traffic, etc.; and 6) record visitors to the site, including their arrival and departure times.

Missing Data

Depending on the amount of time that was missed, the crew used different methodologies to make up for incomplete or missing counts.

If less than 25 minutes were missed the passage rate for the period within that interval was used to estimate passage for the non-sampled portion of the interval.

$$P = 2x_i(30 / m_c) \qquad (1)$$

Where 30 is the number of minutes in a complete sample and m_c is the number of minutes in sample that where actually counted, x_i is the number of fish counted in sample i and 2 is to expand the count for one hour.

If data from one or more complete samples was missing, counts were interpolated by averaging counts from samples before and after the missing sample(s) as follows:

$$P = 2\left(1/n\sum_{i=1}^{n} x_i\right)\begin{Bmatrix} s = 1, n = 4 \\ s = 2, n = 6 \\ s = 3, n = 8 \end{Bmatrix} \quad (2)$$

Where n is the number of samples used for interpolation (half before and half after missing sample(s)), x_i is the count for each sample i, and s is the number of missed samples and 2 is to expand the count for one hour.

If more than three samples were missed, an XY Scatter plot was calculated using the fish counts for the day from both left bank and right bank. The linear regression-line equation was then used to calculate missing fish counts:

$$P_i = 2(a + bx_i) \quad (3)$$

Where a and b are the regression coefficients, x equals the count for sample i on the opposite bank and P_i is the estimated passage for missing sample i.

Equipment Settings

The DIDSON is a high frequency, multi-beam sonar with a unique acoustic lens system designed to focus the beam to create high resolution images. Sound pulses were generated by the sonar at center frequencies of 1.1 MHz. DIDSON simultaneously transmits on, and then receives from sets of 12 beams. Images or frames are built in sequences of these sets of pings. At frequencies of 1.1 MHz, 48 beams (4 sets of 12) 0.6° apart from each other on a horizontal plane are utilized to form the image. The right bank sampled at a range from 0.83 m to 20 m and the left bank sampled at a range from 0.83 to 10 m and the frame rate was set to 4 pings per second.

AGE, SEX, AND LENGTH SAMPLING

Temporal strata, used to characterize the age and sex composition of the chum salmon escapement, were defined as quartiles using dates on which 25%, 50%, 75%, and 100% of the total run had passed the sonar site. To determine current year ASL sampling dates we used the historical mean quartile ASL dates (Table 1). The 2007 quartile-sampling strata were determined postseason based on run timing data. They represent an attempt to sample the escapement for age, sex, and length (ASL) information in relative proportion to the total run. In 2007, these strata were defined as: June 27 to July 3, July 4–8, July 9–14, and July 15–26

To meet region wide standards for the sample size needed to describe a salmon population, the initial seasonal ASL sample goal were 608 chum salmon, with a minimum of 162 chum salmon samples collected during each temporal stratum (Bromaghin 1993). Sample size goals are based on a 95% confidence with an accuracy (d) and precision (α) objectives of d = 0.10 and α = 0.05, assuming two major age classes, and two minor age classes with a scale rejection rate of 15%. The beach seining goal for Chinook salmon was to sample all fish captured while pursuing the chum salmon sampling goal.

A beach seine (31 m long, 66 meshes deep, 6.35-cm mesh) was drifted, beginning approximately 10 m downstream of the sonar site, to capture chum salmon to collect ASL data. All resident freshwater fish captured were tallied by species and released. Pink salmon were counted by sex, based on external characteristics, and released. Chum salmon were placed in a holding pen and each was noted for sex, measured to the nearest 5 mm from mideye to tail fork, and one scale was taken for age determination. Where possible, scales were removed from an area posterior to the base of the dorsal fin and above the lateral line on the left side of the fish (Clutter and Whitesel 1956). The adipose fin was clipped on each sampled chum salmon to prevent resampling. If any Chinook salmon were caught, they were sampled using the same methods as for chum salmon, except three scale samples were taken from each fish.

CLIMATIC AND HYDROLOGIC SAMPLING

Climatic and hydrologic data were collected at approximately 1800 hours each day at the sonar site. Relative river depth was monitored using a staff gauge marked in 1 cm increments. Change in water depth was presented as negative or positive increments from the initial reading of 0.0 cm. Water temperature were measured using a HOBO water temp logger which electronically recorded the temperature six times per day starting at 0245 and again every four hours. The data was downloaded to a computer at the end of the season. Daily maximum and minimum air temperatures were recorded in degrees C. Subjective notes on wind speed and direction, cloud cover, and precipitation were recorded.

DIDSON VS SPLIT-BEAM COMPARISON

The Anvik River sonar project transitioned to DIDSON sonar this year and a side-by-side comparison between the DIDSON and split-beam systems was performed in an attempt to allow more direct comparison with the historical split-beam estimates. DIDSON counts were compared to split-beam counts obtained over the same 30-minute sampling periods using standard linear regression techniques. Because standard linear regression assumes the error to be in the dependent variable, the DIDSON was treated as the independent variable since there was more error in the split-beam counts.

RESULTS

ESCAPEMENT ESTIMATES AND RUN TIMING

Full sonar operations on both banks began on June 28. Both transducers collected data through midnight on July 26. The 2007 summer chum salmon passage estimate were 459,038 (SE 1,881) (Table 2). This includes estimates for missing sector/hourly counts and expansions for missing data for right bank passage on July 1, 2, 11, and 18, and left bank passage on July 1, 2, 11, and 17–20. No pink salmon were observed while conducting visual counts in 2007; therefore, all counts were attributed to summer chum salmon.

Summer chum salmon passage dates were 2–5 days late at each quartile when compared to the historic run timing, based on 1979–1985 and 1987–2006 runs (Table 1). The summer chum passage quartiles were close to the historic median dates. The central half of the run passed between July 5 and July 17 (Table 1) and the duration of 12 days is near the historic mean of 10 days. The daily passage between the first and third quartile dates ranged from 11,058 (July 15) to 27,570 (July 9) with an estimated 257,946 fish passing by the sonar site during this time (Table 2). The peak daily passage of 27,570 summer chum occurred on July 9 (Table 2). No pink salmon were counted in 2007. This was expected since pink salmon usually return to spawn during the even years. The 2007 chum salmon escapement estimate of 459,038 was 72% of the mean Anvik River escapement estimate of 642,269 fish, based on 1979–2006 data (Table 1). This year's escapement fell within the BEG of 350,000 to 700,000 summer chum salmon.

SPATIAL AND TEMPORAL DISTRIBUTION

There was a distinct diurnal pattern to the passage in 2007 with 43% of the counts recorded between the hours of 2100 and 0500 (Figure 4). Spatially, 83.7% of the chum salmon were detected by the right bank sonar (Figure 5).

AGE AND SEX COMPOSITION

From June 30 to July 18, a total of 9 days of sampling was conducted for ASL. The age-0.3 and -0.4 chum salmon accounted for 90.1% of the entire run (Table 3; Figure 6). The age-0.3 chum salmon accounted for 60.5% of the entire run ranging from 55.0% to 65.5% throughout the run. The age-0.4 chum salmon accounted for 32.8% of the run at the beginning and comprised 23.9% of the run by the end. The age-0.2 chum salmon comprised 1.1% of the overall run. There were more females than males throughout the run; overall 58.2% of the run were females (Table 3).

HYDROLOGIC AND CLIMATOLOGICAL CONDITIONS

The summer of 2007 saw warm temperatures and wet conditions on the Anvik River. Due to rain in the headwaters the water level fluctuated at the sonar site throughout the season (Figure 7). The minimum air temperature was 4°C (June 30) and a maximum high of 32°C (July 9) with an average high and low of 23°C and 8°C (Figure 8). Water temperatures were measured six times per day (0245, 0645, 1045, 1445, 1845, 2245) the lowest average temperature by time was 9.7°C at 0245 the highest average temperature was 16.6°C at 1845 (Figure 9). The average temperature over the operational period of the project was 13.7°C (Figure 8). The temperature averaged 13.3°C between the hours of 02:45 and 10:45 and 14.1°C from 14:45 to 22:45.

DIDSON VS SPLIT-BEAM COMPARISON

The split-beam was operated adjacent to the DIDSON on both banks from July 17–25, for a total of 184 paired counts on left bank and 188 paired counts on right bank. Left bank the minimum hourly split-beam count was 8 and the maximum hourly count was 642; the DIDSON minimum hourly count was 6 and the maximum hourly count was 788 (Figure 10). Figure 11 shows the minimum counts were similar between the split-beam and DIDSON whereas the maximum counts are not as similar between the sonars. For right bank the minimum hourly split-beam count was 74 and the maximum hourly count was 710; the DIDSON minimum hourly count was 82 and the maximum hourly count was 1,008 (Figure 12). Figure 13 shows the minimum counts are similar between the split-beam and DIDSON, whereas the maximum counts are not as similar between the sonars.

DISCUSSION

ESCAPEMENT ESTIMATION

The 2007 Anvik River summer chum salmon escapement estimate of 459,038 was 29% below the 1979–2006 average escapement of 642,269 and 54% below last year's DIDSON escapement estimate (992,378). This is the third year since 2002 that the summer chum salmon abundance has been within the BEG. Although the exact reason for the low salmon runs in past years is unknown, scientists speculate that poor marine survival results from, or is accentuated by, localized weather conditions in the Bering Sea (Kruse 1998).

ASL Sampling

Age and sex composition of the Anvik River chum salmon passing the sonar site changes through the duration of the run. Usually, the trend is an increasing proportion of younger salmon and a higher proportion of female salmon as the run progresses (Fair 1997). The 2003 chum salmon year class returned to spawn this year as age-0.3, accounting for 60.5% (277,560) of the total run. Age 0.4 fish accounted for 29.6% (135,858) and age-0.5 accounted for 8.8% (40,366) of the total run. The large number of returning chum salmon from the 2001 (age 0.5) year class over the last several years is encouraging considering the 2001 year class was the second lowest spawning year since 1979 (Table 2).

The average age of the 2007 run was 4.5 years which is about even with the long-term average of 4.4 years (Figure 14) and there were 58.2% females which are above the long-term average of 55.9%.

SPATIAL AND TEMPORAL DISTRIBUTION

In 2007, chum salmon spatial migration followed historical trends with 83.8% of fish passing on the right bank. Prior to 2006, passage has been associated with the right bank with the exception of 3 years: 1992, 1996, and 1997. In these years only 43%, 45%, and 39% of the adjusted passage occurred on the right bank, respectively (Sandone 1994a; Fair 1997; Chapell 2001). The shift to the left bank in those years was attributed to low water conditions that affected chum salmon migration patterns at the sonar site. Although there is no river stage benchmark at the site to allow direct comparison with previous years, subjectively, the water level in 2007 appeared to be lower then last year.

Buklis (1982) first reported a distinct diurnal salmon migration pattern during the 1981 season with a higher proportion of the migration passing the sonar site during darker hours of the day. Similar diurnal patterns were reported from 1985 through 2005. Temporal distribution of sonar estimates in 2007 indicates a distinct diurnal pattern (Figure 4). The chum salmon could be migrating in greater numbers at night due to the fact that the water is slightly cooler (0.8°C) or to escape predation from various birds and mammals.

DIDSON VS SPLIT-BEAM COMPARISON

Although a strong trend was observed between the split-beam and DIDSON counts, the range of the data is not sufficient to allow direct comparison with previous years. This is particularly true of the right bank side-by-side comparison where the range of counts was 74 to 710 fish per hour. Contrast this with the 2005 field season where the range of counts was 22 to 1700 fish per hour – the maximum was more than twice that observed in the comparison. The 2005 season was not unique and substantial portions of the runs in other years fall beyond the range of our comparison. Given the uncertainty associated with predicting outside the range of our comparison data, we do not plan on using this relationship to adjust historical estimates.

ACKNOWLEDGEMENTS

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TABLES AND FIGURES

Table 1.–Annual passage estimates and associated passage timing statistics for summer chum salmon runs, Anvik River sonar, 1979–2007.

						Days Between Quartiles			
Year	Sonar passage estimate	Day of first Salmon Count	First Quartile day	Median day	Third Quartile day	First count & first quartile	First & median	Median & third	First & third
1979	277,712	6/23	7/02	7/08	7/12	9	6	4	10
1980	482,181	6/28	7/06	7/11	7/16	8	5	5	10
1981	1,479,582	6/20	6/27	7/02	7/07	7	5	5	10
1982	444,581	6/25	7/07	7/11	7/14	12	4	3	7
1983	362,912	6/21	6/30	7/07	7/12	9	7	5	12
1984	891,028	6/22	7/05	7/09	7/13	13	4	4	8
1985	1,080,243	7/05	7/10	7/13	7/16	5	3	3	6
1986	1,085,750	6/21	6/29	7/02	7/06	8	3	4	7
1987	455,876	6/21	7/05	7/12	7/16	14	7	4	11
1988	1,125,449	6/21	6/30	7/03	7/09	9	3	6	9
1989	636,906	6/20	7/01	7/07	7/13	11	6	6	12
1990	403,627	6/22	7/02	7/07	7/15	10	5	8	13
1991	847,772	6/21	7/01	7/10	7/16	10	9	6	15
1992	775,626	6/29	7/05	7/08	7/12	6	3	4	7
1993	517,409	6/19	7/05	7/12	7/18	16	7	6	13
1994	1,124,689	6/19	7/01	7/07	7/11	12	6	4	10
1995	1,339,418	6/19	7/01	7/06	7/11	12	5	5	10
1996	933,240	6/18	6/25	7/01	7/06	7	6	5	11
1997	605,752	6/19	6/28	7/03	7/10	9	5	7	12
1998	487,301	6/22	7/05	7/10	7/14	13	5	4	9
1999	437,356	6/27	7/06	7/10	7/16	9	4	6	10
2000	196,349	6/21	7/08	7/11	7/13	17	3	2	5
2001	224,058	6/26	7/06	7/10	7/15	10	4	5	9
2002	459,058	6/22	7/03	7/07	7/12	11	4	5	9
2003	256,920	6/21	7/05	7/10	7/15	14	5	5	10
2004	365,353	6/22	6/29	7/05	7/09	7	6	4	10
2005	525,391	6/26	7/04	7/10	7/15	8	6	5	11
2006	605,485	6/28	7/03	7/06	7/12	5	3	6	9
2007	459,038	6/27	7/05	7/10	7/17	8	5	7	12
Mean	642,269	6/22	7/02	7/08	7/12	10	5	5	10
Median	517,409	6/22	7/03	7/08	7/13	10	5	5	10
SD	348,043		3.5	3.2	3.0	3	2	1	2

Note: The mean and standard deviation of the timing statistics includes estimates from years 1979–1985 and 1987–2003. In 1986, sonar counting operations were terminated early, probably resulting in the incorrect calculation of the quartile statistics. Therefore, the 1986 run timing statistics were excluded from the calculation of the overall mean and timing statistic and associated standard deviation (SD). From 1979–2003 Bendix sonar was used and from 2004–2006 HTI sonar was used, in 2007 DIDSON sonar was used.

Table 2.–Summer chum daily and cumulative counts, Anvik River sonar, 2007.

	Right Bank		Left Bank		Daily Total		Cumulative	
Date	Count	Expanded counts *	Count	Expanded counts *	Count	Expanded counts	Expanded counts	Percent Passage
6/27	1,956	1,956	840	840	2,796	2,796	2,796	0.6%
6/28	8,448	8,448	1,202	1,202	9,650	9,650	12,446	2.7%
6/29	6,816	6,816	510	510	7,326	7,326	19,772	4.3%
6/30	10,346	10,346	640	669	10,986	11,015	30,787	6.7%
7/1	12,287	12,287	1,924	1,924	14,211	14,211	44,998	9.8%
7/2	15,837	15,837	1,696	1,696	17,534	17,534	62,532	13.6%
7/3	16,176	17,278	1,008	1,276	17,184	18,554	81,086	17.7%
7/4	7,922	14,330	2,161	2,441	10,083	16,771	97,857	21.3%
7/5	17,506	17,506	2,857	2,857	20,363	20,363	118,220	25.8%
7/6	17,686	17,686	1,569	1,569	19,255	19,255	137,475	29.9%
7/7	19,696	19,696	3,088	3,088	22,784	22,784	160,259	34.9%
7/8	18,870	19,499	1,924	1,938	20,794	21,437	181,695	39.6%
7/9	24,542	24,542	3,028	3,028	27,570	27,570	209,265	45.6%
7/10	22,550	24,064	2,372	2,708	24,922	26,772	236,037	51.4%
7/11	16,052	16,052	2,110	2,110	18,162	18,162	254,199	55.4%
7/12	13,415	13,910	1,527	1,556	14,943	15,466	269,666	58.7%
7/13	15,310	15,310	2,422	2,422	17,732	17,732	287,398	62.6%
7/14	16,976	16,976	1,568	1,568	18,544	18,544	305,942	66.6%
7/15	10,336	10,336	722	722	11,058	11,058	317,000	69.1%
7/16	16,160	16,160	2,134	2,173	18,294	18,333	335,333	73.1%
7/17	14,804	14,804	5,666	5,666	20,470	20,470	355,803	77.5%
7/18	14,990	14,990	10,026	10,026	25,016	25,016	380,819	83.0%
7/19	11,362	11,362	7,976	7,976	19,338	19,338	400,157	87.2%
7/20	9,012	9,012	4,482	4,482	13,494	13,494	413,651	90.1%
7/21	6,606	6,606	1,618	1,618	8,224	8,224	421,875	91.9%
7/22	4,306	4,306	758	758	5,064	5,064	426,939	93.0%
7/23	6,558	6,558	1,568	1,568	8,126	8,126	435,065	94.8%
7/24	7,106	7,106	1,904	1,904	9,010	9,010	444,075	96.7%
7/25	5,510	5,510	1,864	1,957	7,374	7,467	451,542	98.4%
7/26	5,214	5,537	1,631	1,960	6,845	7,496	459,038	100.0%
Season Totals	374,356	384,826	72,795	74,212	447,152	459,038		

Note: The large box indicates the central 50% of the run (second and third quartiles).

Note: * Expanded due to missing data.

Table 3.–Age and sex composition of chum salmon, Anvik River sonar, 2007. Number fish is based on the sonar estimate divided by percent of fish in age class and stratum.

			AGE									
			(0.2)		(0.3)		(0.4)		(0.5)		Total	
Sample Date (Strata)	Sample Size	Sex	Number Fish	%	Number Fish	%	Number Fish	%	Number Fish	%	Number Fish	%
6/30-7/2	137	Male	592	0.7	18,348	22.6	14,205	17.5	5,327	6.6	38,471	47.4
(6/27-7/3)		Female	0	0.0	27,818	34.3	12,429	15.3	2,367	2.9	42,615	52.6
		Subtotal	592	0.7	46,166	56.9	26,634	32.8	7,694	9.5	81,086	100.0
7/5-6	141	Male	0	0.0	28,542	28.4	11,417	11.3	3,568	3.5	43,526	43.3
(7/4-8)		Female	1,427	1.4	34,250	34.0	18,552	18.4	2,854	2.8	57,083	56.7
		Subtotal	1,427	1.4	62,791	62.4	29,969	29.8	6,422	6.4	100,609	100.0
7/10-11	140	Male	0	0.0	31,062	25.0	23,074	18.6	6,212	5.0	60,348	48.6
(7/9-14)		Female	0	0.0	37,274	30.0	19,524	15.7	7,100	5.7	63,898	51.4
		Subtotal	0	0.0	68,335	55.0	42,599	34.3	13,312	10.0	124,246	100.0
7/17-18	142	Male	0	0.0	34,501	22.5	11,860	7.7	4,593	2.1	49,595	32.4
(7/15-26)		Female	3,234	2.1	65,767	43.0	24,797	16.2	9,703	6.3	103,502	67.6
		Subtotal	3,234	2.1	100,268	65.5	36,657	23.9	12,938	8.5	153,097	100.0
Season Total	560	Male	592	0.1	112,452	24.5	60,555	13.2	18,341	4.0	191,940	41.8
		Female	4,662	1.0	165,109	36.0	75,303	16.4	22,025	4.8	267,098	58.2
		Total	5,253	1.1	277,560	60.5	135,858	29.6	40,366	8.8	459,038	100.0

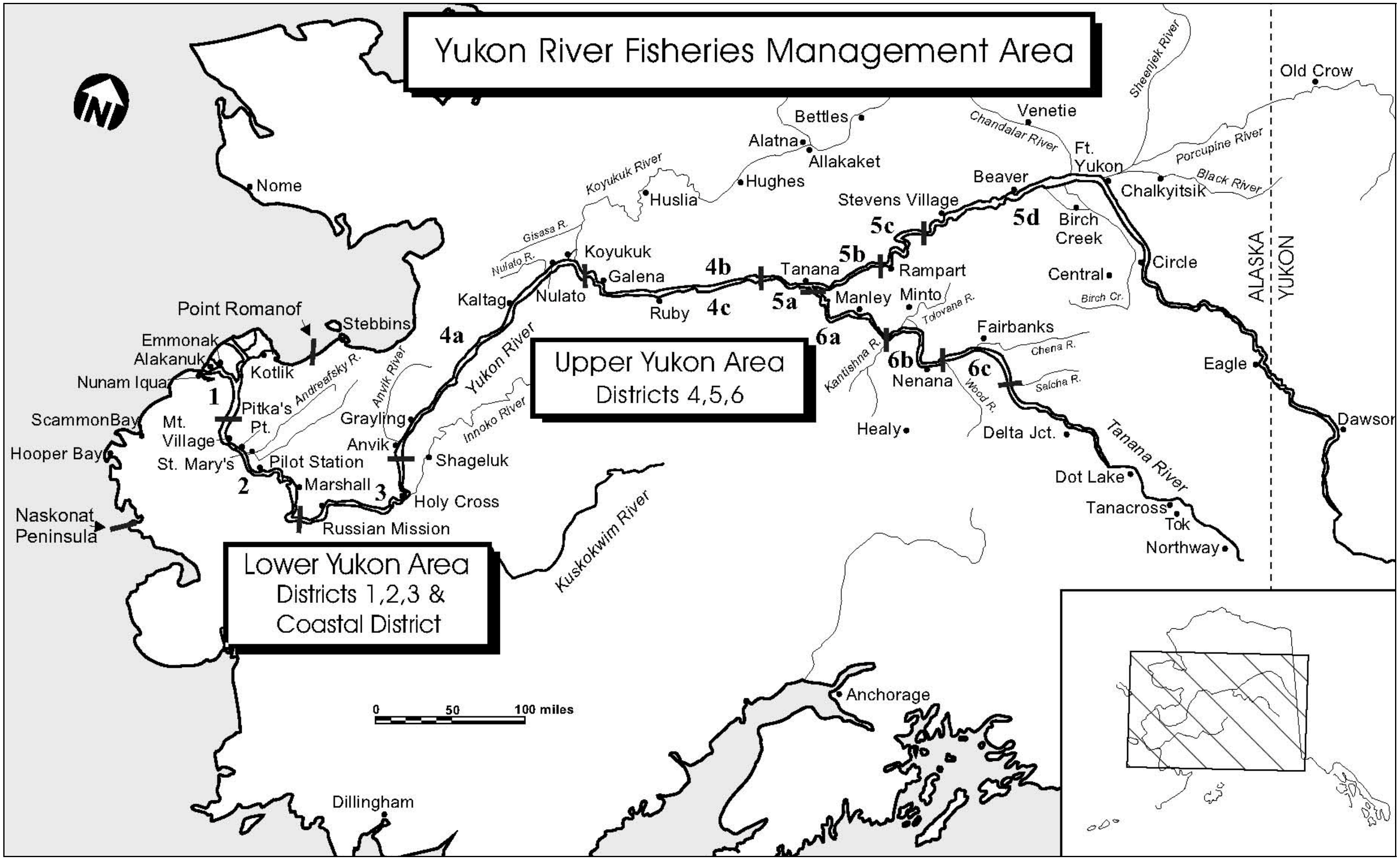


Figure 1.–Alaska portion of the Yukon River drainage showing communities and fishing districts.

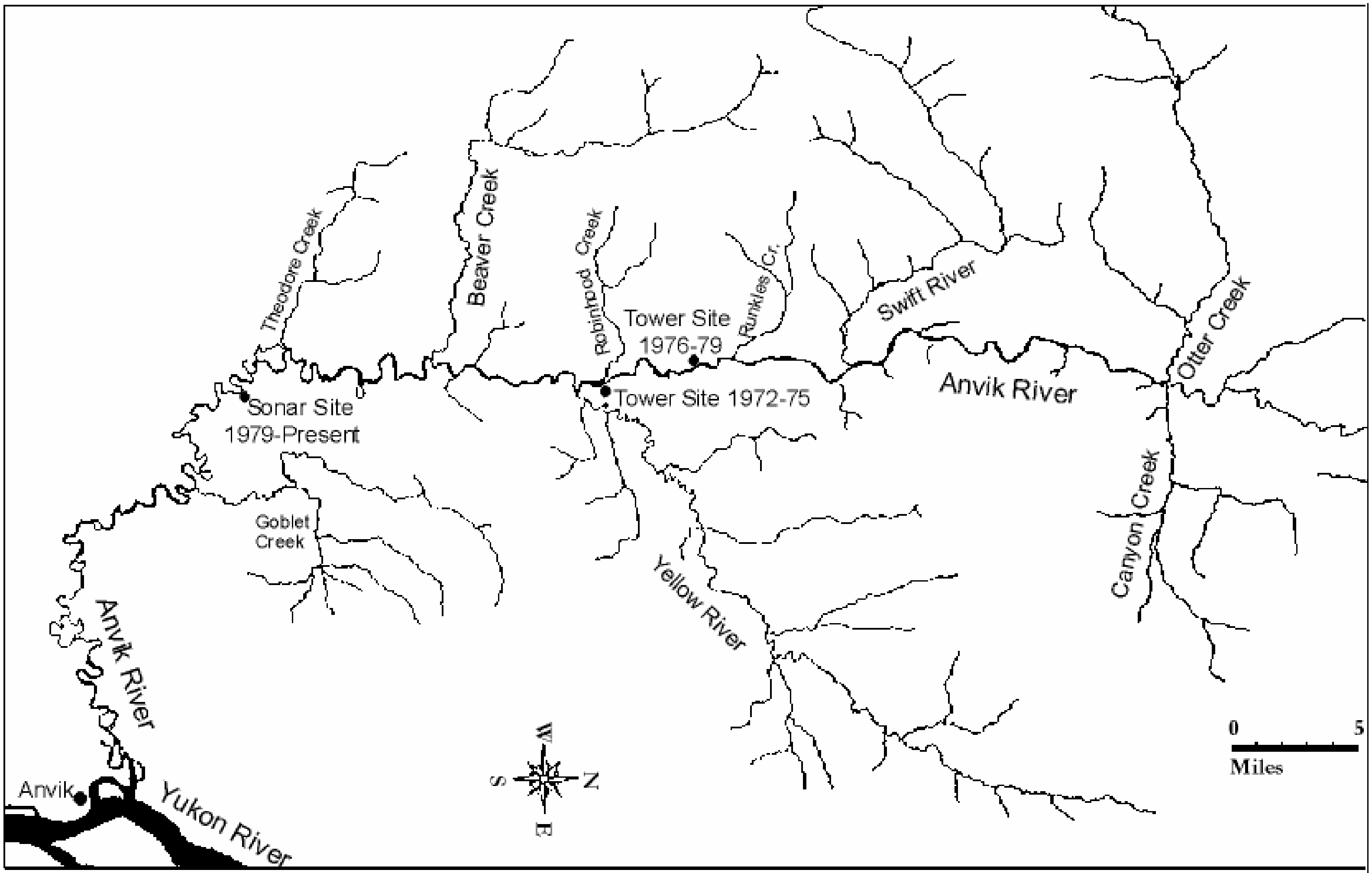


Figure 2.–Anvik River drainage with historical chum salmon escapement project locations.

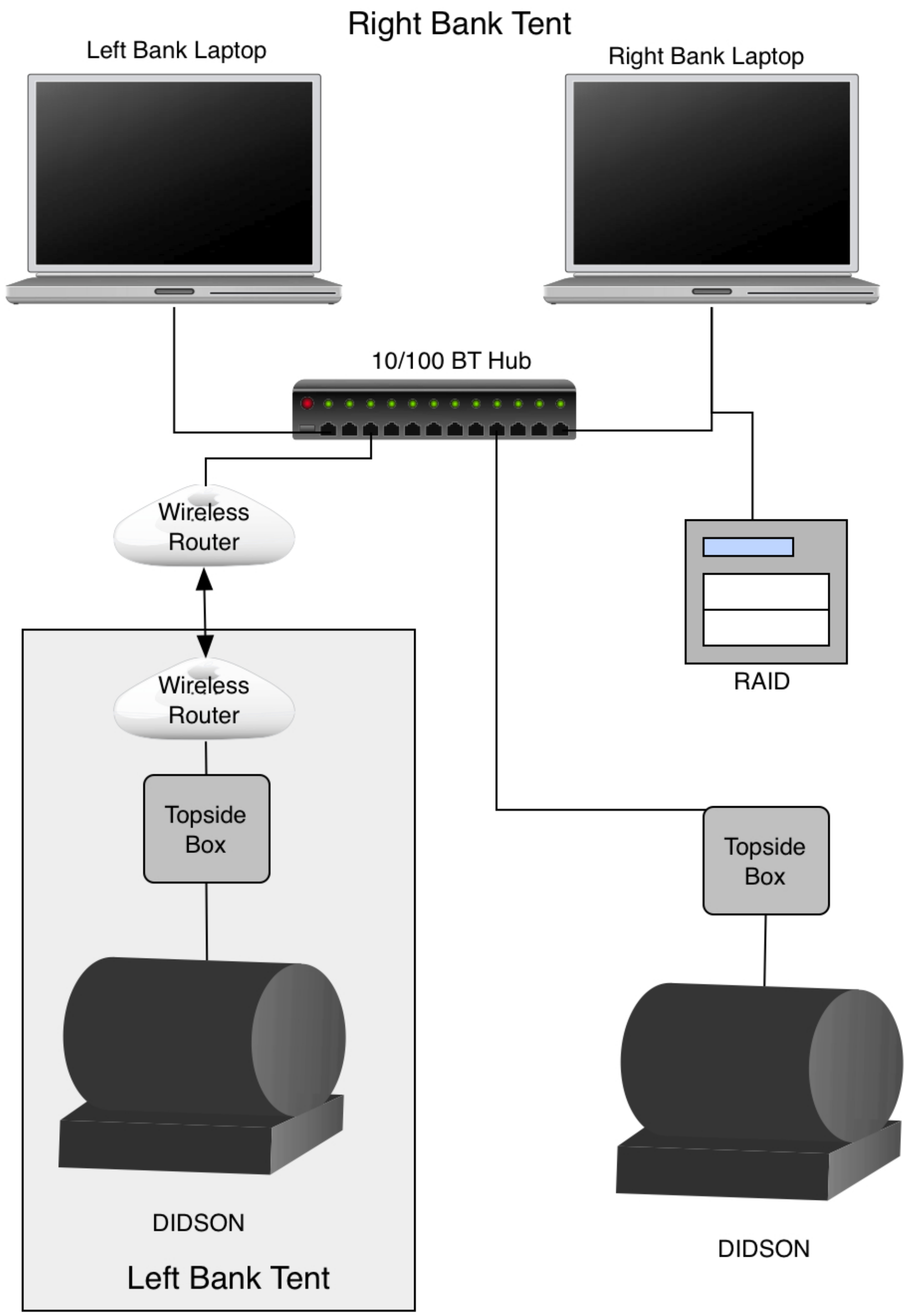


Figure 3.–DIDSON Sonar equipment schematic, Anvik River Sonar, 2007.

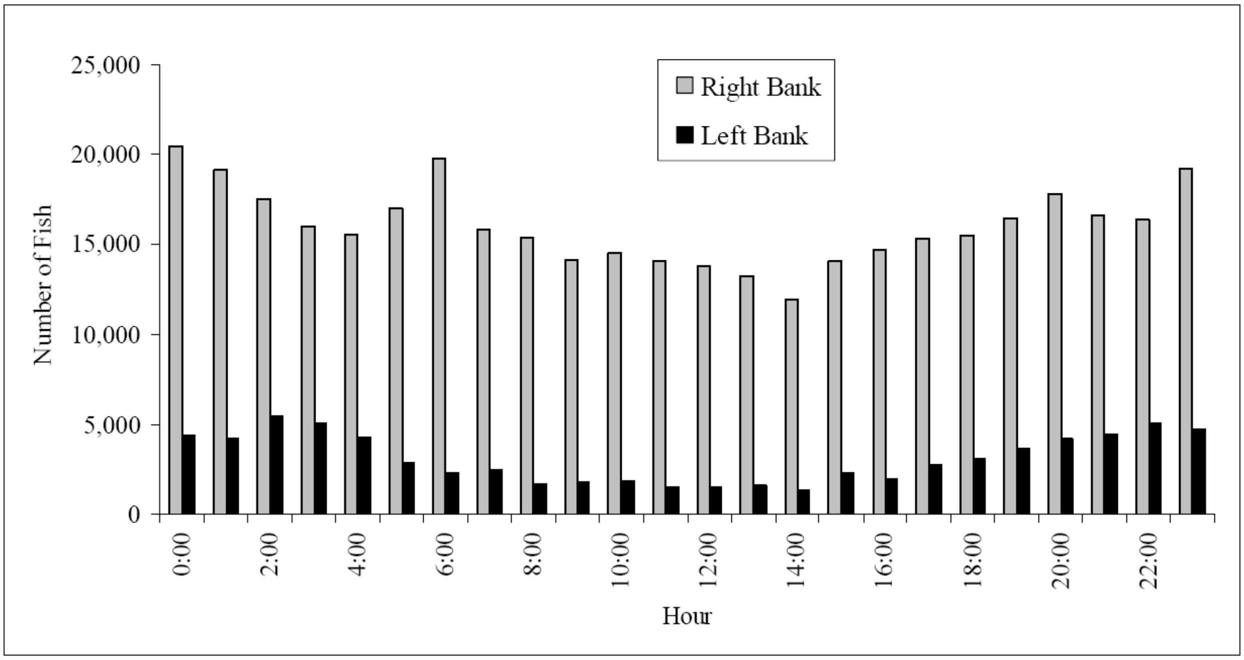


Figure 4.–Estimated passage of chum salmon by hour for each bank, Anvik River sonar 2007.

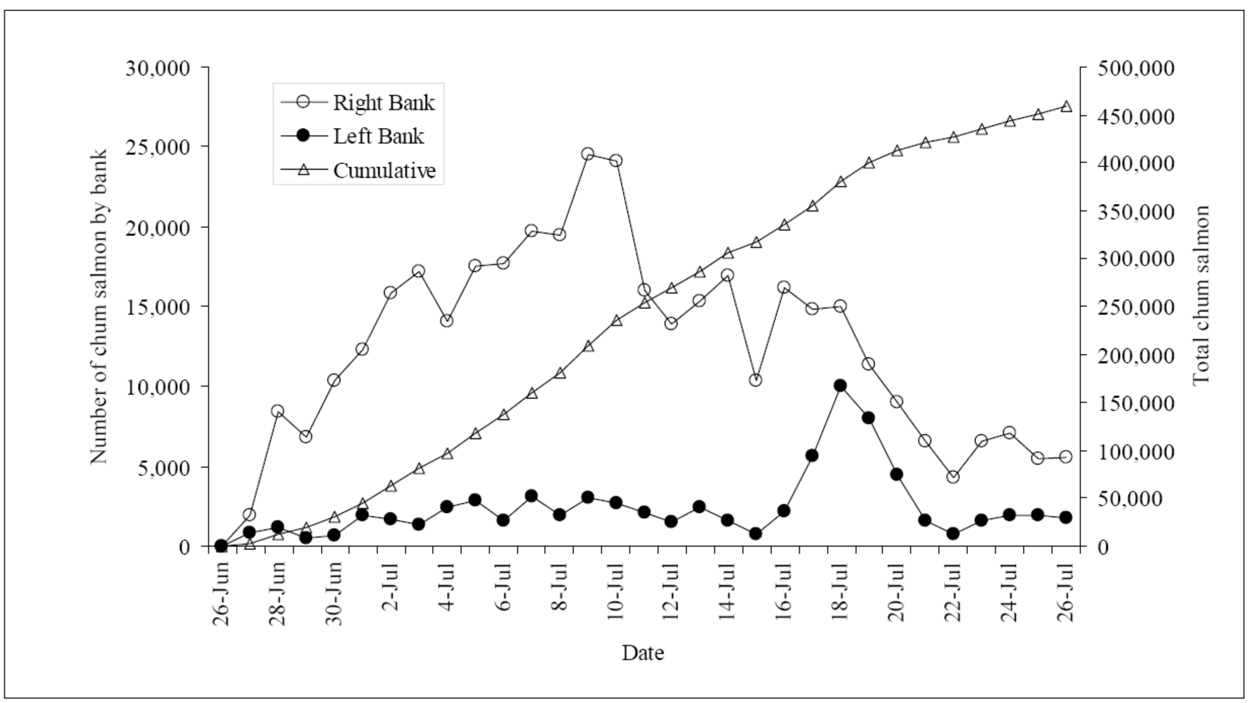


Figure 5.–Chum salmon daily and cumulative counts, Anvik River sonar 2007.

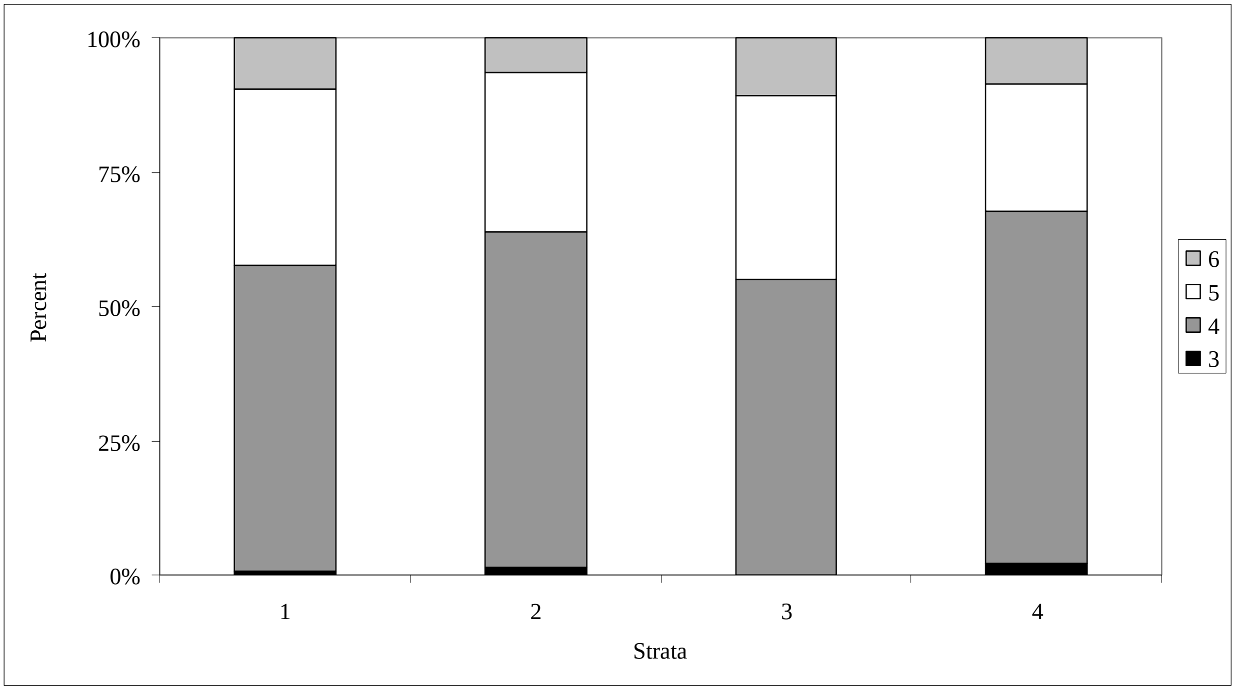


Figure 6.–Chum salmon age composition, Anvik River sonar, 2007.

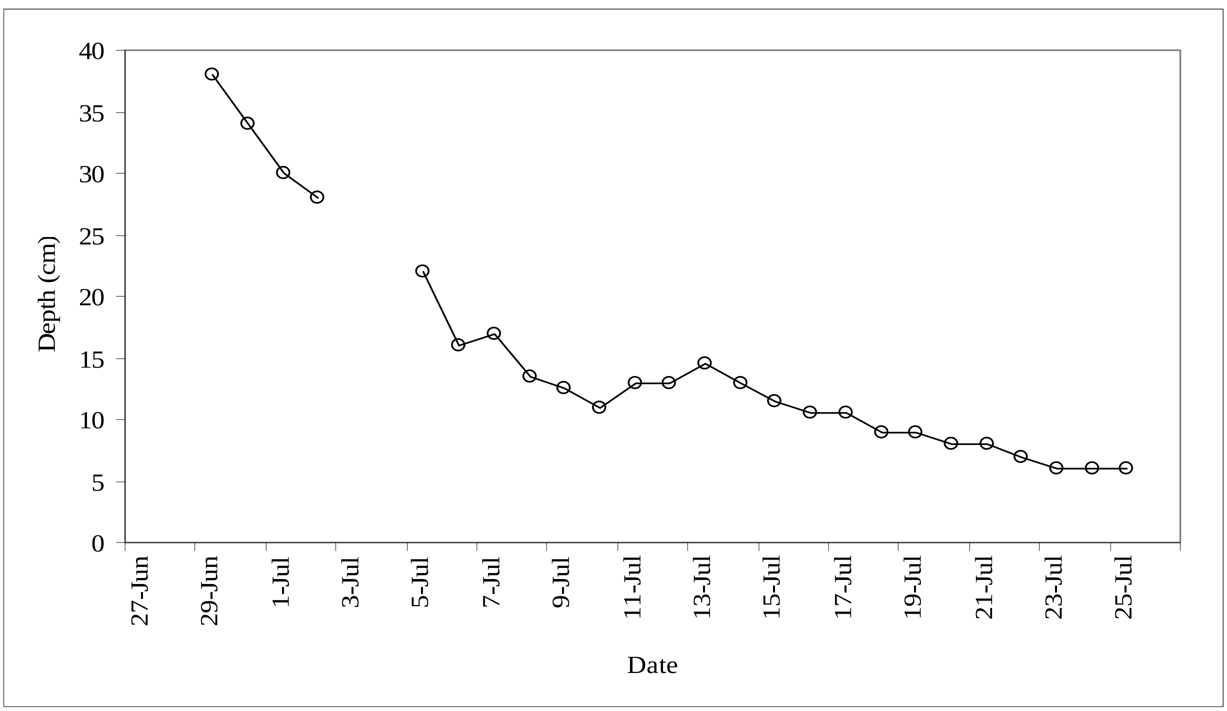


Figure 7.–Water level by day at Anvik River sonar, 2007.

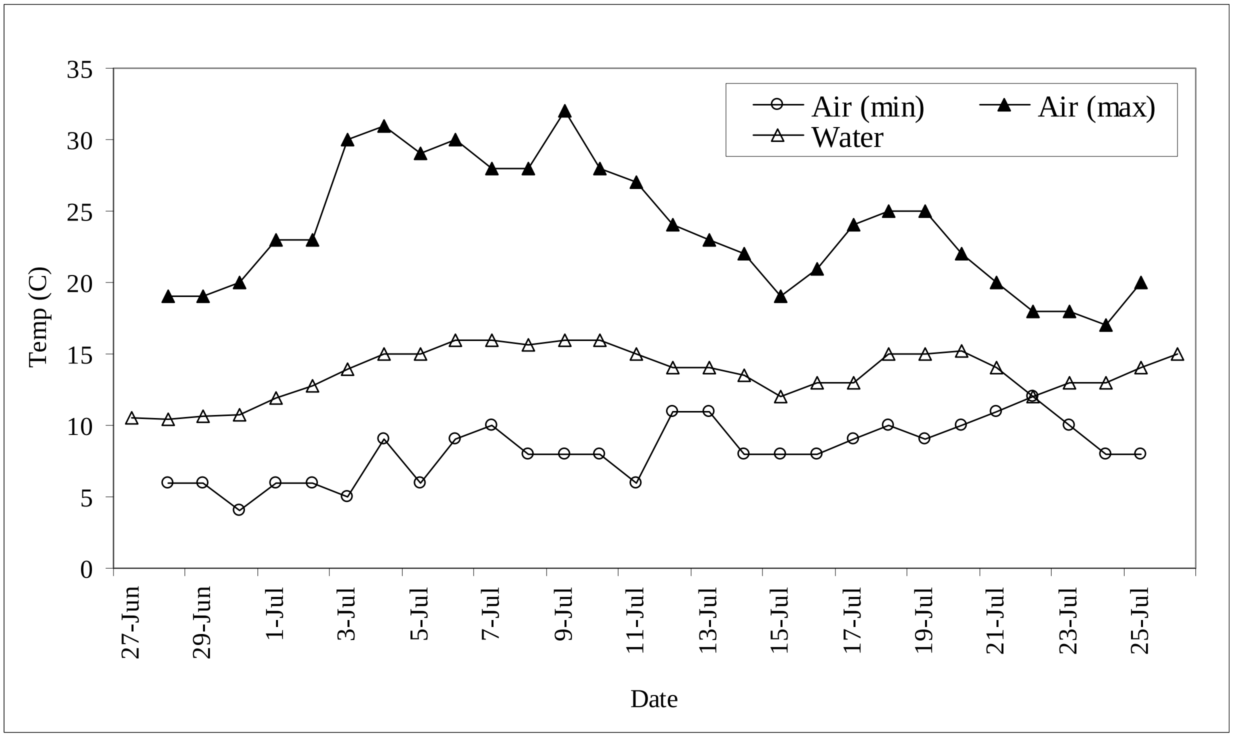


Figure 8.–Daily air and average water temperature, Anvik River sonar, 2007.

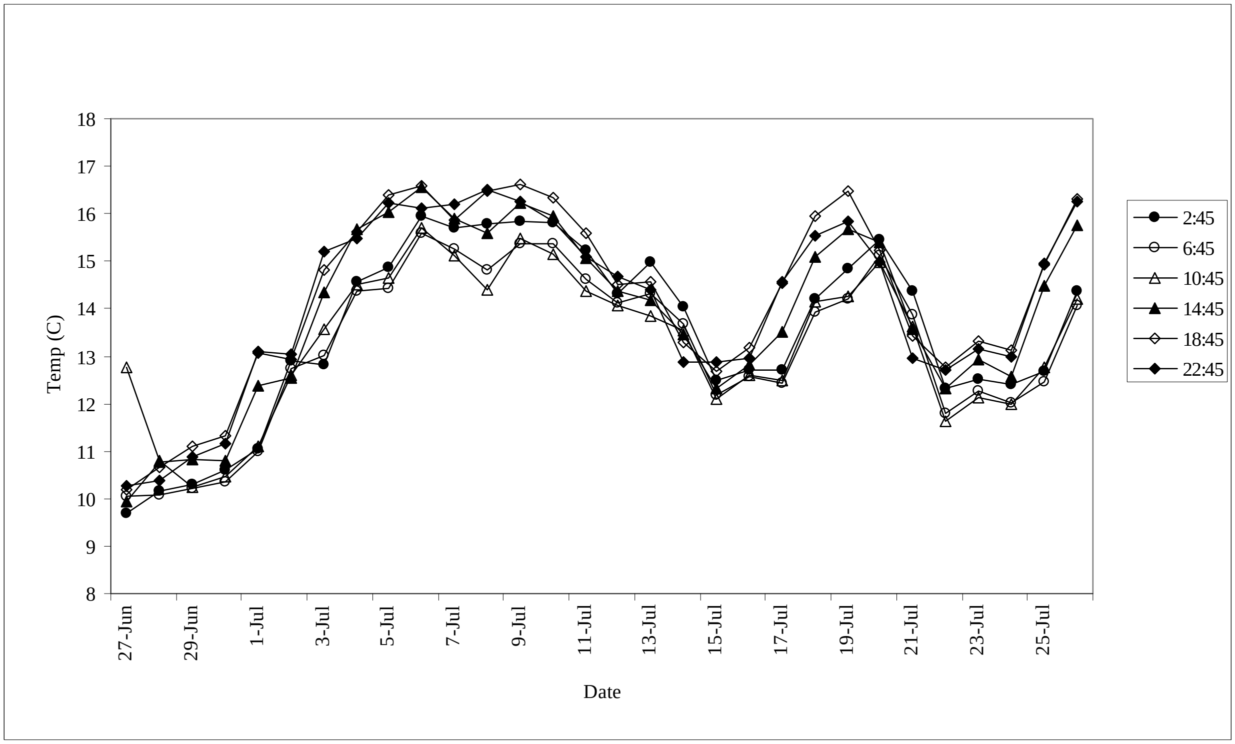


Figure 9.–Daily water temperature by time, Anvik River sonar, 2007.

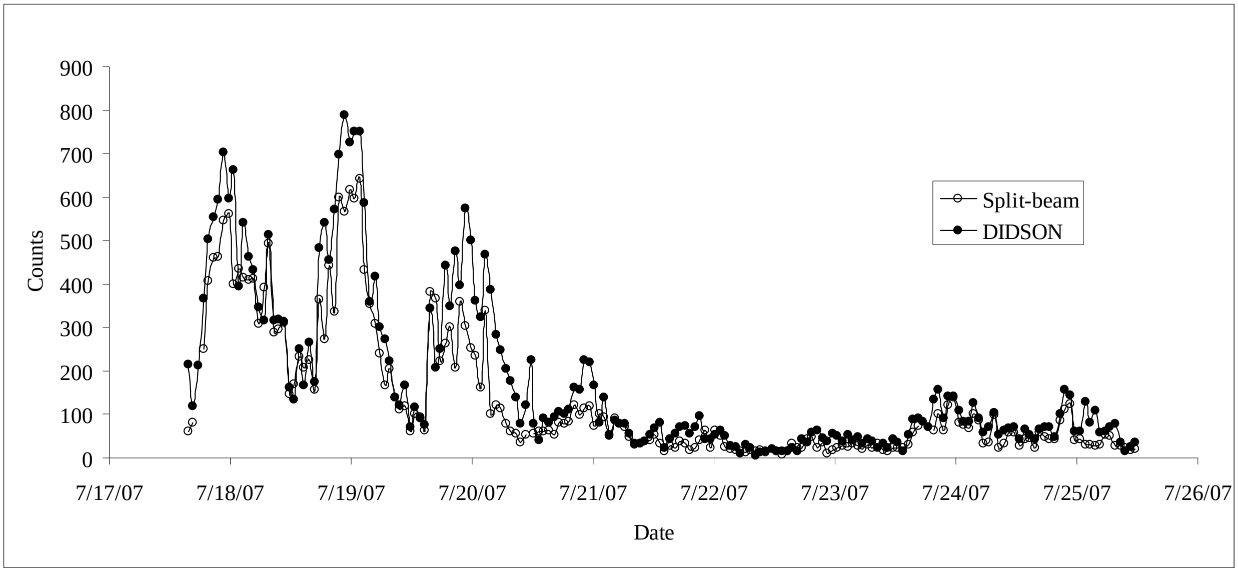
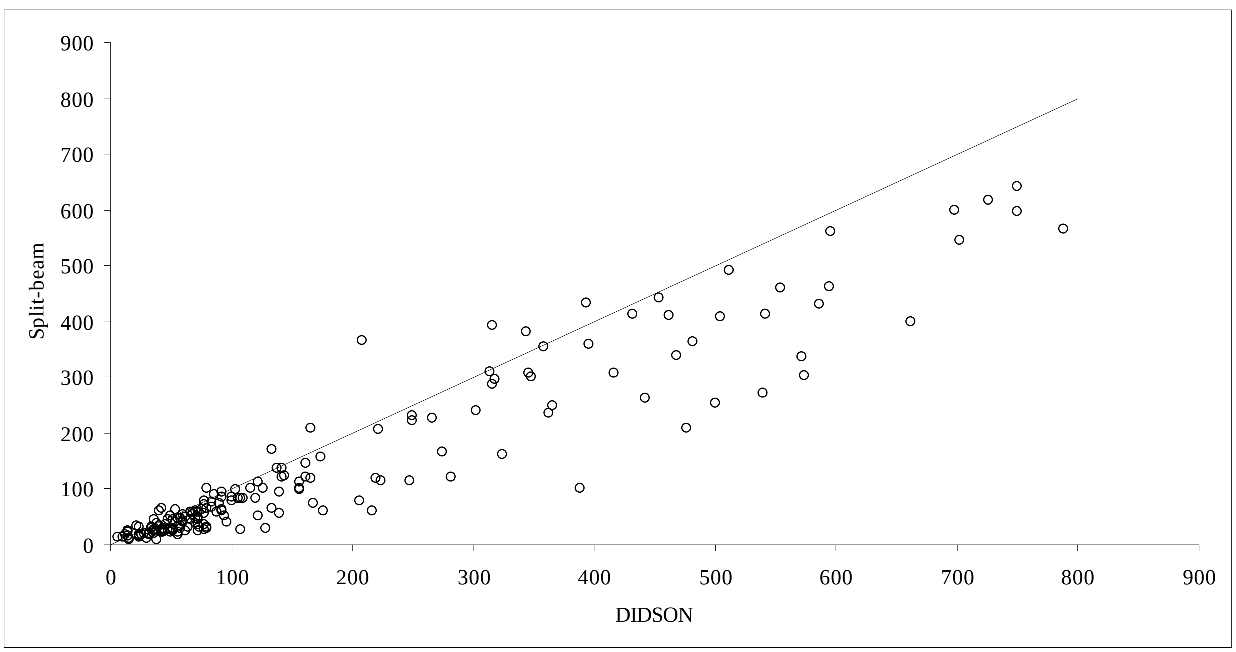


Figure 10.–Left bank split-beam and DIDSON comparison counts, Anvik River Sonar 2007.



Note: The trend line is where x and y equal each other.

Figure 11.–Left bank split-beam and DIDSON scatter plot comparison counts, Anvik River Sonar 2007.

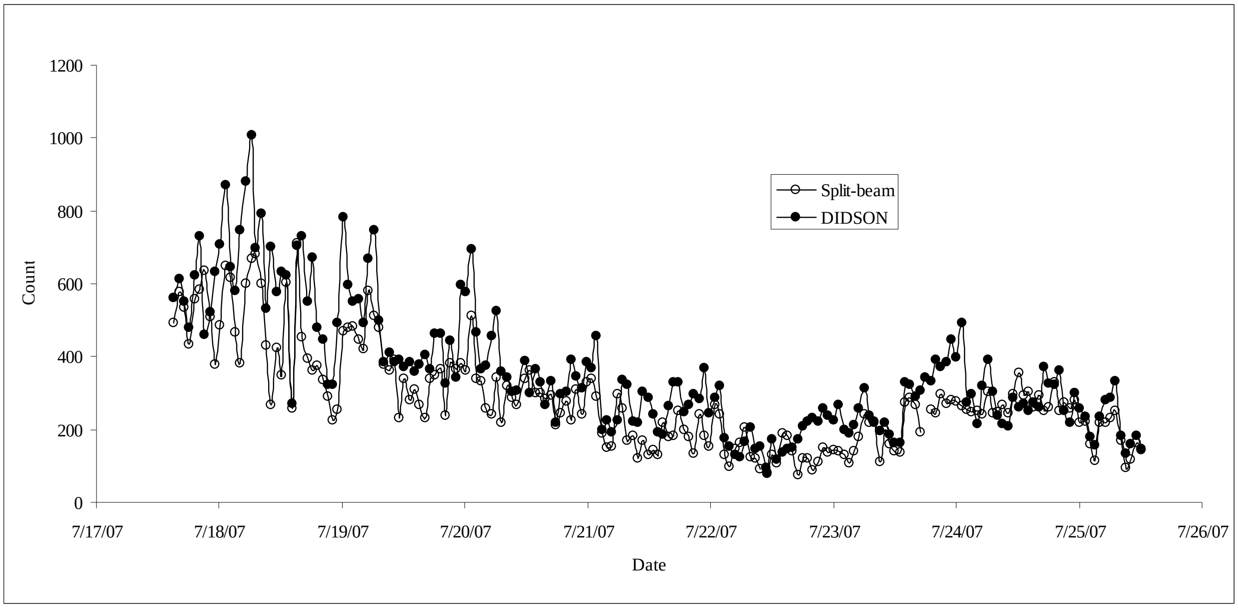
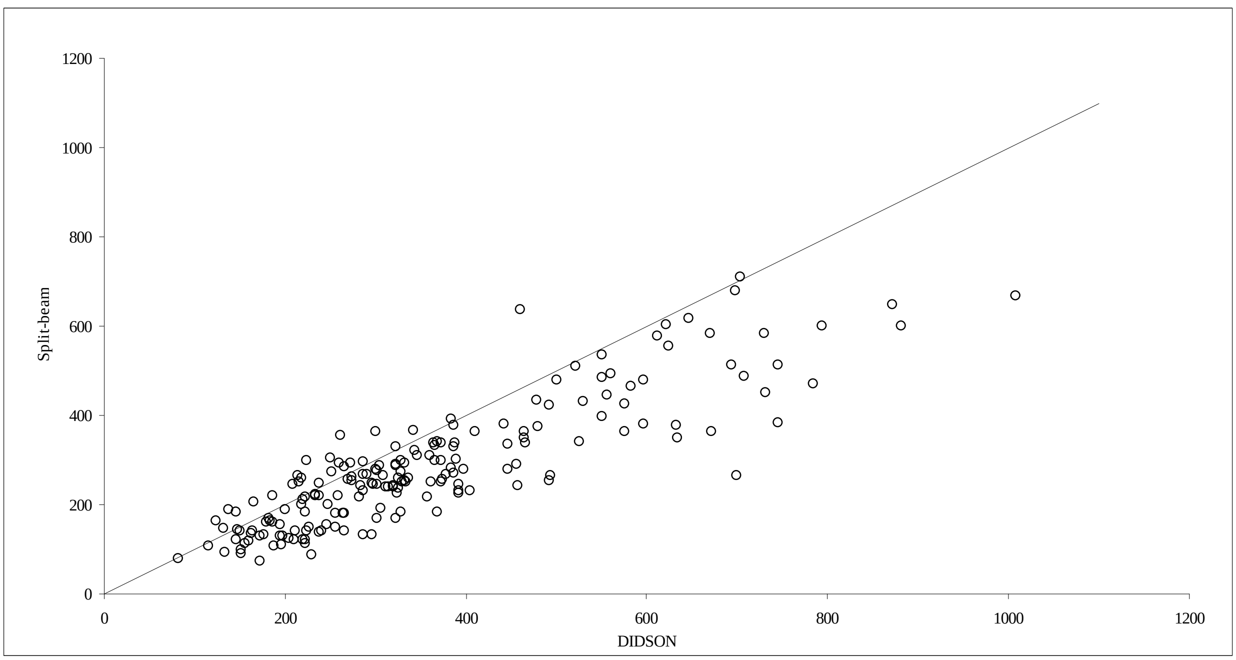
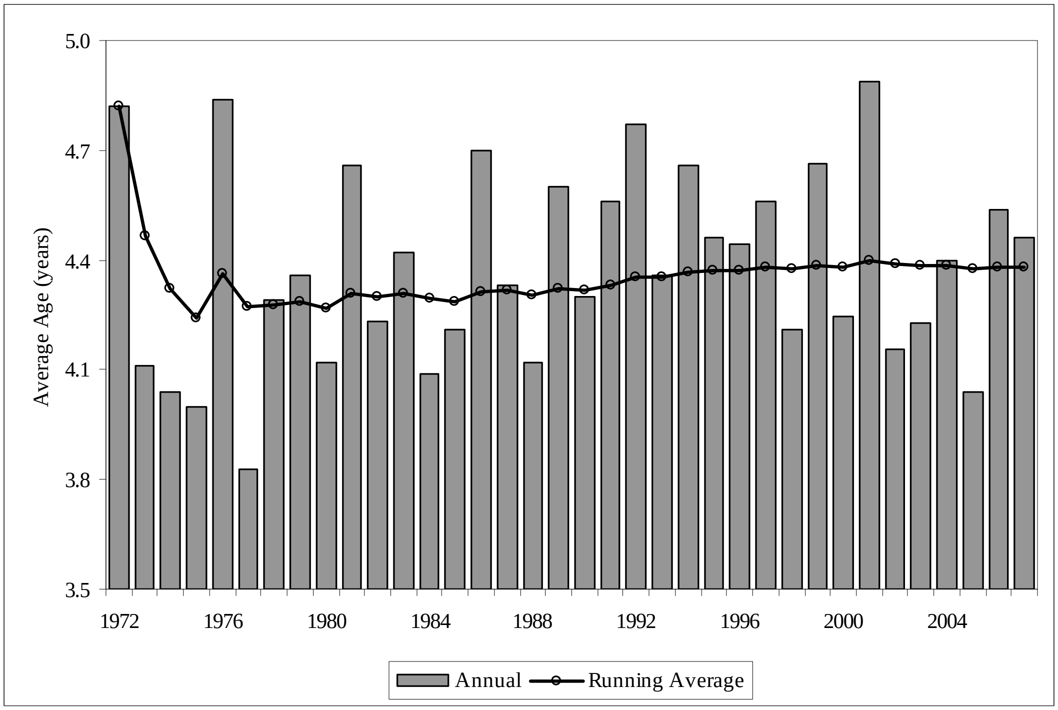


Figure 12.–Right bank split-beam and DIDSON comparison counts, Anvik River Sonar 2007.



Note: The trend line is where x and y equal each other.

Figure 13.–Right bank split-beam and DIDSON scatter plot comparison counts, Anvik River Sonar 2007.



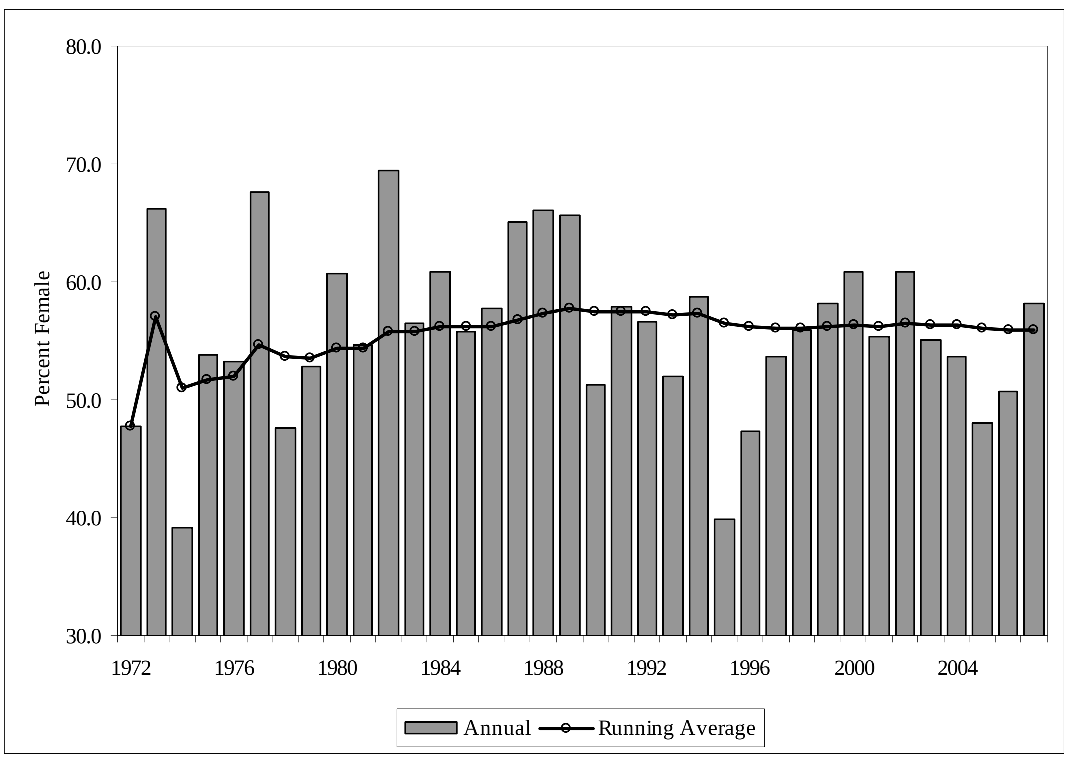


Figure 14.–Annual age at maturity (top) and percentage of females (bottom) of the Anvik River chum salmon escapement, 1972–2007.